Nuclear Safety Workshop

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Working Together to Enhance Nuclear Safety

Nuclear Regulatory Commission Handling of Beyond Design Basis Events for Nuclear Power Reactors

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Regulatory/Safety Considerations

- Evolving Relationships and Requirements
  - Event selection and assessment
  - Safety classification of equipment (special treatment)
  - Analyses methodologies (deterministic/risk assessments)
  - Plant design and equipment
  - Configuration management and operating limits
  - Defense in depth
  - Regulatory (or safety) requirements

Definitions

- ***Design basis events*** are defined as conditions of normal operation, including anticipated operational occurrences, design basis accidents, external events, and natural phenomena for which the plant must be designed to ensure the following functions:

  (1) The integrity of the reactor coolant pressure boundary

  (2) The capability to shut down the reactor and maintain it in a safe shutdown condition; or

  (3) The capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the applicable guideline exposures set forth in § 50.34(a)(1) or § 100.11 of this chapter, as applicable.

Definitions

- ***Safety-related*** *structures, systems and components* means those structures, systems and components (SSCs) that are relied upon to remain functional during and following **design basis events** to assure:

  (1) The integrity of the reactor coolant pressure boundary

  (2) The capability to shut down the reactor and maintain it in a safe shutdown condition; or

  (3) The capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the applicable guideline exposures set forth in § 50.34(a)(1) or § 100.11 of this chapter, as applicable.

Definitions

- *Design bases* means that information which identifies the specific functions to be performed by a structure, system, or component of a facility, and the specific values or ranges of values chosen for controlling parameters as reference bounds for design. These values may be (1) restraints derived from generally accepted "state of the art" practices for achieving functional goals, or (2) requirements derived from analysis (based on calculation and/or experiments) of the effects of a postulated accident for which a structure, system, or component must meet its functional goals.

- The “design bases” for an SSC therefore includes its functions for both “design-basis events” and “beyond-design-basis events”

Evolution of design basis events (and beyond design basis)

- Early concept as maximum credible accidents
  - Defined required plant features
    - Example – safety related and non-safety related
  - Emergency preparedness as last line for protecting public health
- Recognition of insights from risk assessments
  - Reactor Safety Study
  - Policy statements on safety goal, PRA, and severe accidents
  - Individual Plant Examinations
- Expansion of “important to safety” in new regulations
  - Station Blackout (SBO)
  - Anticipated Transients without Scram (ATWS)

Evolution of design basis events (and beyond design basis)

- Evolution of assessments and treatment of beyond design basis
  - Additional actions for BDBAs
    - Severe accident mitigation alternatives (SAMA)
    - Severe accident management guidelines (SAMGs)
- Incorporation of risk assessments into regulatory structure
  - Risk Informed Licensing
    - Regulatory Guide 1.174
  - Required risk assessment summary for new reactors
    - Regulatory treatment of non-safety systems (RTNSS)
  - Risk assessment for plant maintenance (10 CFR 50.65(a)(4))
  - Risk informed categorization and treatment (10 CFR 50.69)
  - Reactor oversight (significance determination process)

Characteristics

- Design Basis
  - Deterministic modeling
  - Established analysis methods, assumptions, and decision criteria
  - Determined design specifications for safety related SSCs
  - Basis for limiting conditions for operation
- Beyond design basis
  - Many sequences using best estimate models
  - Used to evaluate sensitivities, vulnerabilities, and interactions
  - Used to identify risk approaches
    - Contingencies, capabilities and strategies

Balancing of technical analysis techniques

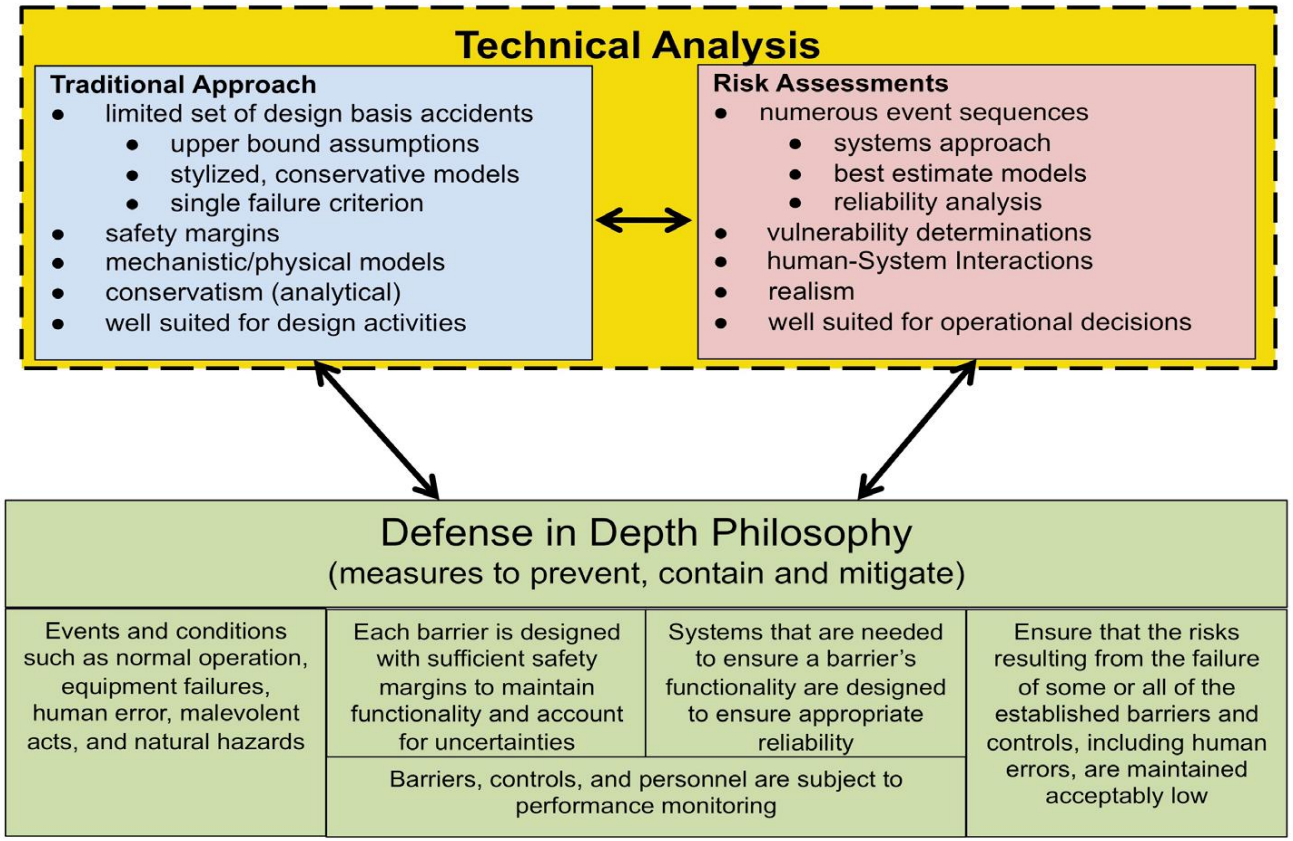

Figure B-3 Balancing Risk Assessments and Deterministic Techniques

NUREG-2150

International Activities

WENRA Revised Levels of Defence in Depth

	Level of defence in depth	Objective of the level	Essential means	Associated plant condition categories	Radiological consequences
Original design of the plant	Level 1	Prevention of abnormal operation and failure	Conservative design and high quality in construction and operation	Normal operation	Regulatory operating limits for discharge
	Level 2	Control of abnormal operation and failure	Control, limiting and protection systems and other surveillance features	Anticipated operational occurrences	Regulatory operating limits for discharge
	Level 3 (1)	Control of accident to limit radiological releases and prevent escalation to core damage conditions (2)	Safety systems Accident procedures	DiD Level 3.a Postulated single initiating events	No off-site radiological impact or only minor radiological impact (see NS-G-1.2/4.102)
		Control of accident to limit radiological releases and prevent escalation to core melt conditions (3)	Engineered safety features (4) Accident procedures	DiD Level 3.b **Selected multiples failures events** including possible failure or inefficiency of safety systems involved in DiD level 3.a	
	Level 4	**Practical elimination of situation that could lead to early or large releases of radioactive materials** **Control of accidents with core melt to limit off-site releases**	**Engineered safety features to mitigate core melt** **Management of accidents with core melt (severe accidents)**	**Postulated core melt accidents (short and long term)**	Limited protective measures in area and time
Emergency planning	Level 5	Mitigation of radiological consequences of significant releases of radioactives materials	Off-site emergency response Intervention levels	-	Off site radiological impact necessitating protective measures

From WENRA-Safety Objectives for New Power Reactors-December 2009

Event Categories & IAEA Scale

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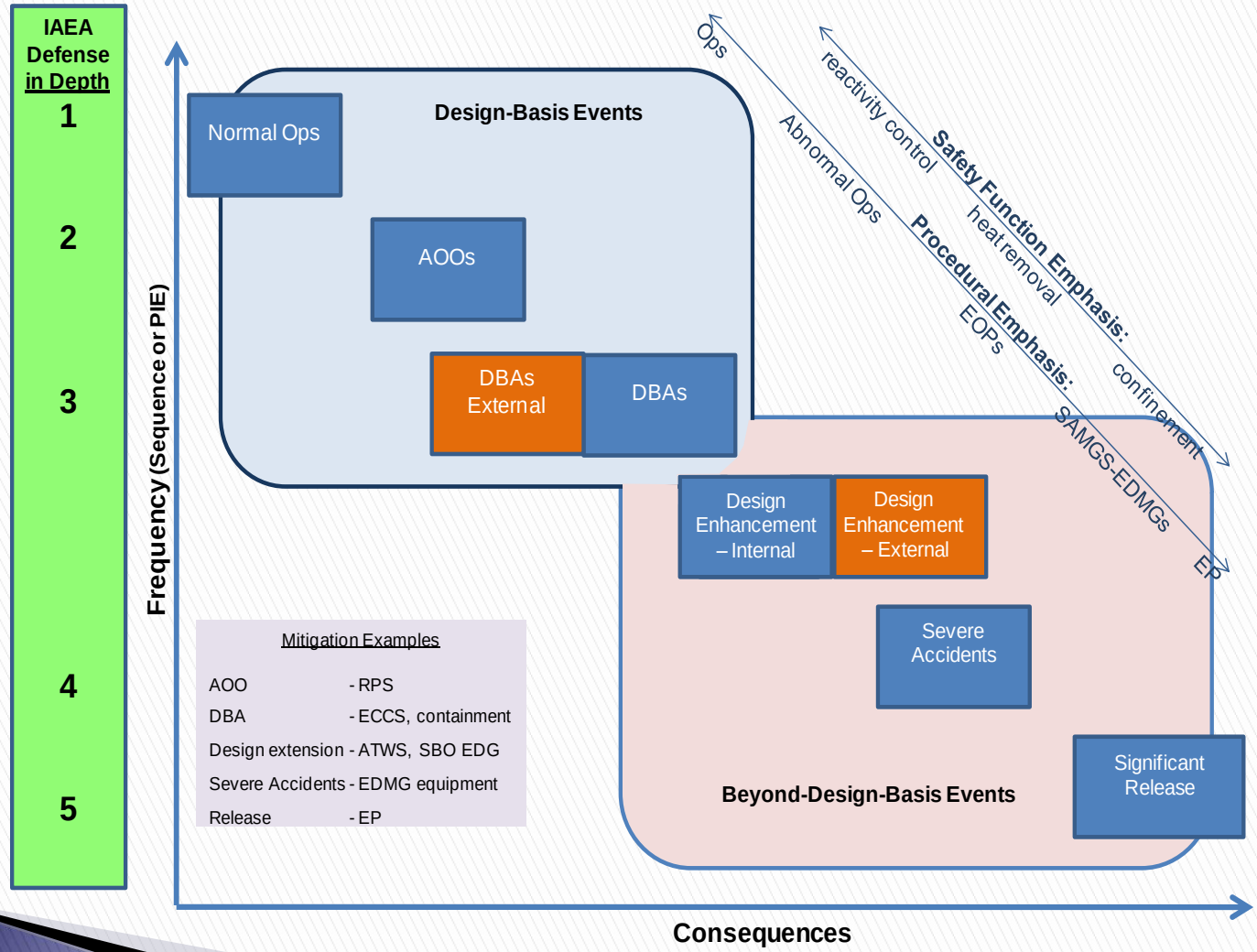

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Proposed Risk Management Regulatory Framework (NUREG-2150)

Risk Management Goal

Provide risk-informed and performance-based defense-in-depth protections to:

- Ensure appropriate barriers, controls, and personnel to prevent, contain, and mitigate exposure to radioactive material according to the hazard present, the relevant scenarios, and the associated uncertainties; and
- Ensure that the risks resulting from the failure of some or all of the established barriers and controls, including human errors, are maintained acceptably low

Possible Incorporation of Design Extension (Enhancement)

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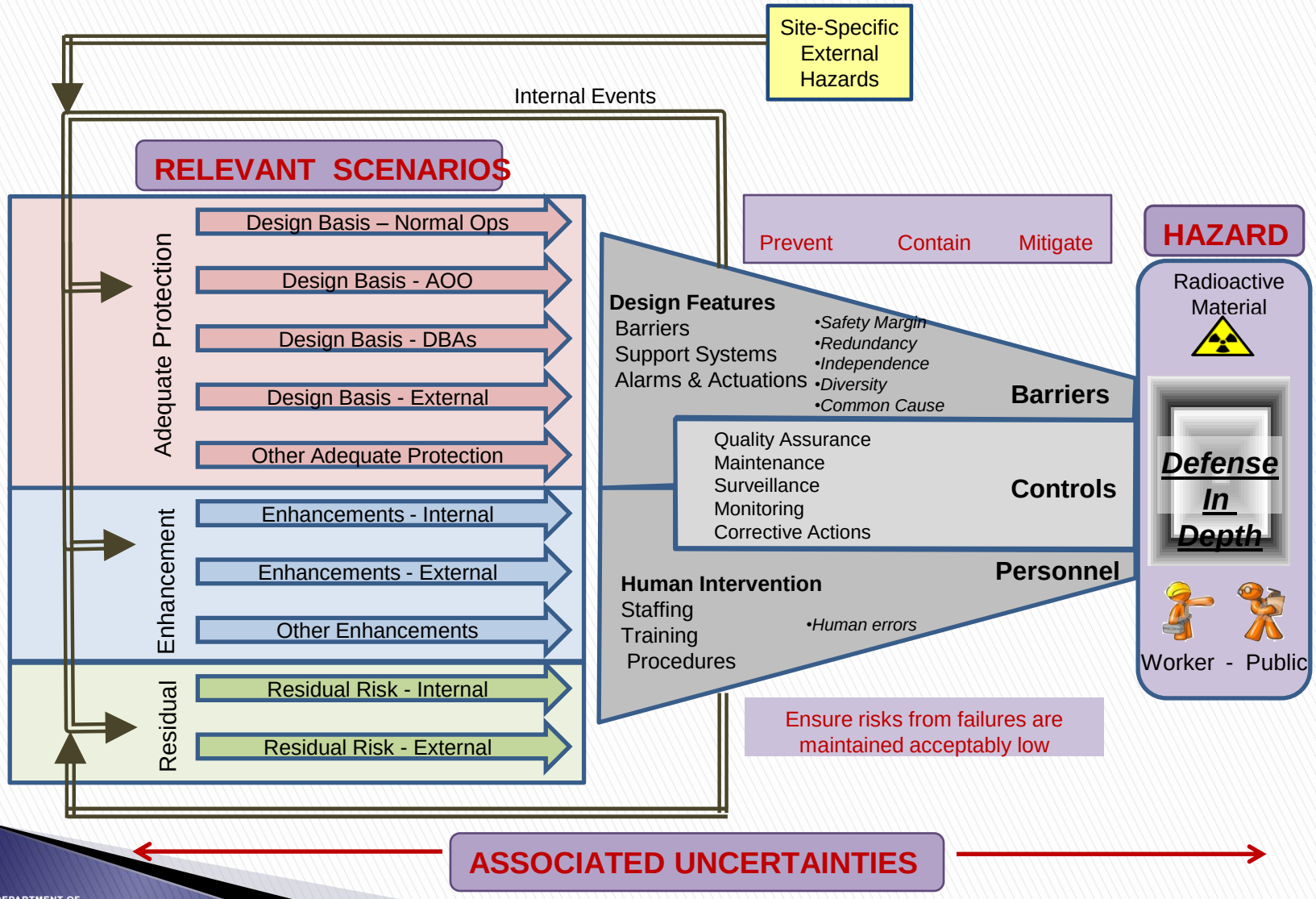

Possible Insights

- Establish Structure, Define Relationships
  - Event selection and assessment
  - Safety classification of equipment (special treatment)
  - Analyses methodologies (deterministic/risk assessments)
  - Plant design and equipment
  - Configuration management and operating limits
  - Defense in depth
  - Regulatory (or safety) requirements